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Poster paper

The development of a harmonic rejection mirror on XAFS beamline at Shanghai Synchrotron Radiation Facility

F. YUAN†, X. SONG, W. XIANGJUN, J. ZHENG, G. SONGQI, C. MING, H. YUYING AND Y. XIAOHAN

Shanghai Institute of Applied Physics, Chinese Academy of Sciences (CAS)

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A harmonic rejection mirror (HRM) can apply pure spectrum for X-ray Absorption Spectrum (XAFS) experiment. The HRM mechanism includes a mirror holding system, a horizontal switch system and a three-point adjustment system. We analyse and calculate the design of the mechanism. Finally, we evaluate the HRM capability based on the rocking curve obtained in a test.

1. Introduction

In Shanghai Synchrotron Radiation Facility, BL14W1 is a general-purpose XAFS beamline. The main optical components include a collimation mirror, a liquid nitrogen-cooled double-crystal monochromator (DCM) with two sets of Si crystals (Si (111) and Si (311)), a focusing mirror and a harmonic rejection mirror. DCM provides output beams that contain unwanted harmonic energies since higher orders of diffraction are unavoidable. For XAFS measurement, a rigorously harmonic-free beam is required. There should be a low-energy harmonic rejection mirror in order to maintain high spectrum purity when the photon energy is under 3.5 keV. Considering the reflector mirrors' cost, the harmonic rejection is put on the end of BL14W1 which is 41 m far from the light source (Xiaohan, 2006). The two reflector mirrors are parallel. Their length, width and height are 260, 70, 30 mm and 260, 83, 30 mm, respectively.

2. Design of a harmonic rejection mirror system

In a harmonic rejection mirror system, a double mirror with three different reflector strips, Si(substrate), Ni(50 nm) and Rh(50 nm), is designed for harmonic rejection in the energy range of 3.5–6.0, 5.5–8.0 and 6.5–12 keV, respectively. The cladding width is 20 mm and thickness is 50 nm. The mirror's surface roughness is 0.3 nm and slope error is 2 arcsec. The incident angle is 5 mrad and harmonic rejection can be realized easily only by a horizontal switch of the strips with respect to different energies (Xiangjun & Yuan, 2007).

† Email address for correspondence: fuyuan@sinap.ac.cn

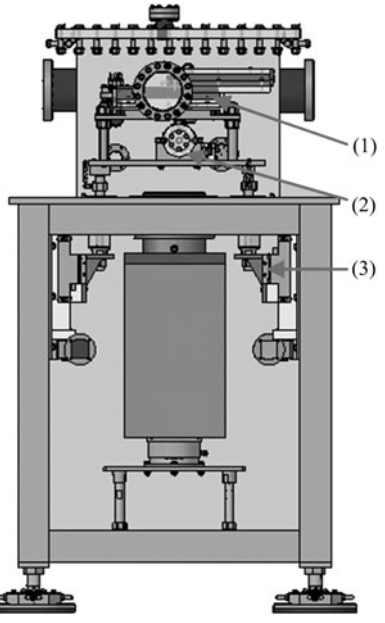

FIGURE 1. Sketch of the harmonic rejection mirror: (1) mirror-holding system, (2) horizontal switch system and (3) three-point adjusting system.

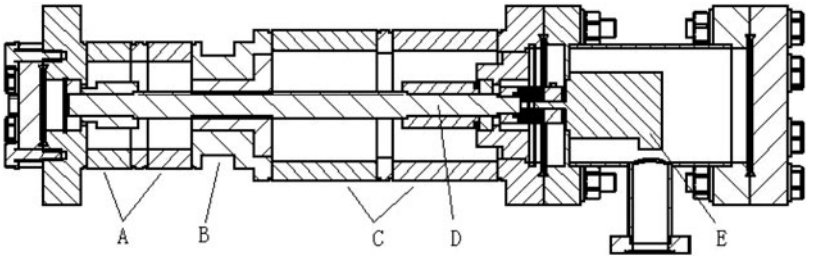

FIGURE 2. Horizontal switch driver system (A,C) bellows (B) switch holder (D) screw (E) drive motor.

The harmonic rejection mirror system has the following requirements and functions: keeping two reflector mirrors parallel; incidence angle adjustment; pitch angle inspection; roll angle and pitch angle adjustment; reflector strip switch in *X*-direction and position indication; movement in vertical direction. The mechanical structure of a harmonic rejection mirror system includes three parts: a mirror-holding system, a horizontal switch system and a three-point adjusting system. The sketch is shown in figure 1.

The mirror-holding system includes two rectangular troughs with a 0.2 mm-thick gasket assembled by several pieces of aluminium boards (Zhenji & Qisheng, 2006). After the mirror is cased, the system is fixed by bolts in different directions. The mirrors should be kept parallel at a distance of 0.6 mm after the assembly.

The horizontal switch system causes the mirrors' horizontal movement. The motor drives the ballscrew and makes the whole mirror-holding system move on a straight-line guide. The maximum gap between the pillar and linear bearing is

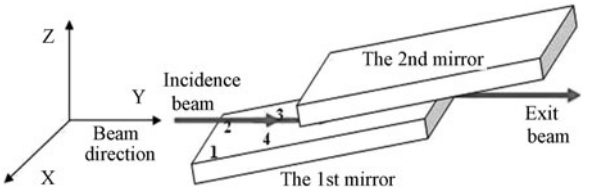

FIGURE 3. Sketch for testing the harmonic rejection mirror.

Points	1–4	2–3	1–2	3–4
Two-points distance (mm)	96.869	95.492	63	63
Two-points distance in vertical direction of plane A (mm)	0.02	0.022	0.003	0.001
Angle of two planes (degree)	0.012 (pitch)	0.013 (pitch)	0.003 (roll)	0.001 (roll)
Parallelism (mm)	0.02 *Y*-direction	0.022 *Y*-direction	0.003 *X*-direction	0.001 *X*-direction

TABLE 1. Test results of the harmonic rejection mirror

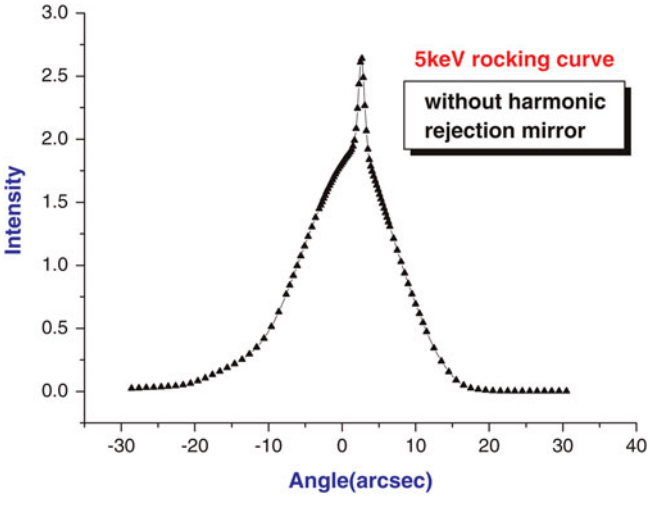

FIGURE 4. 5KeV rocking curve without harmonic rejection mirror

0.008 mm. The effective distance travelled by the ballscrew is 300 mm and the deviation is 0.023 mm. When the motor drives the screw, the bellows shown as A and C in figure 2 become longer or shorter, respectively. There is a connector assembled on position B, which pulls the mirror-holding system. The whole structure is separated from high vacuum by bellows. There are three grating scales used to inspect the vertical movement.

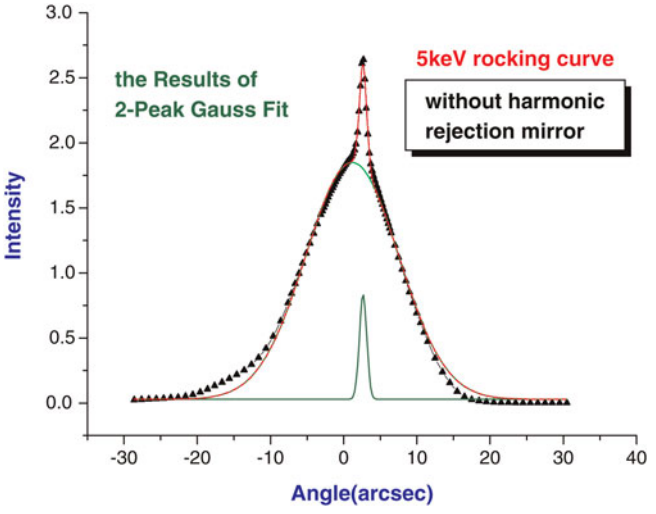

FIGURE 5. Result of two-peak Gauss fitting of the curve of figure 4

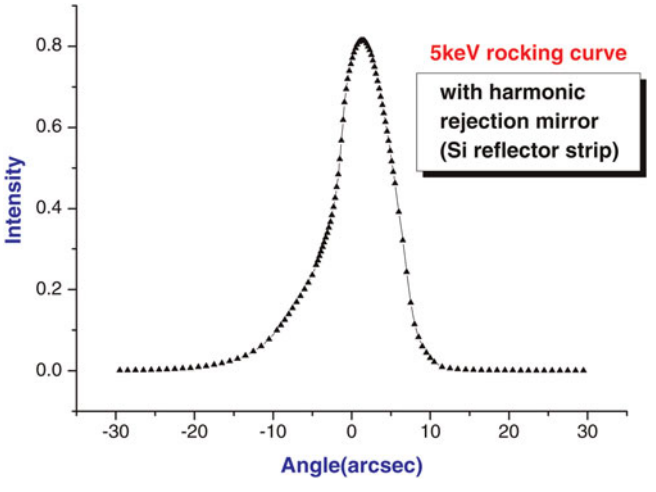

FIGURE 6. 5KeV rocking curve with harmonic rejection mirror

The vertical movement and pitch, roll angle adjustment are realized by the three-point adjusting system. In the pitch adjustment mechanism, the ballscrew repeatability is 8 μm and the worm gear transmission error is 0.14 mm. The total error of the pitch angle we calculated is 0.0047°. The lead of the M32 ballscrew we used is 4 mm. Its gear ratio is 50. So the pitch angle resolution is 0.001°. In the same way, we get the roll angle's resolution to be 0.002°. They are all in accordance with our design targets.

3. Harmonic rejection mirror capability test and experiment result

The mirror holding system is tested by a three-coordinate measuring machine. Three points on the second mirror are measured to construct plane A. Four points

on the first mirror are measured to calculate the distance between each point with plane A. Figure 3 shows the test way and table 1 shows the test result.

One limit switch is taken as a reference point in the reflector strips' switch test. The switch is accomplished by a five-phase motor. In a three-point adjustment system, three-step motors can adjust the mirrors' position and height. The range, resolution, repeatability of roll angle, pitch angle and height reach the design targets.

Figure 4 shows a 5 KeV rocking curve without a harmonic rejection mirror. Figure 5 represents the result of two-peak Gauss fitting of the curve. Figure 6 shows a 5 KeV rocking curve with the harmonic rejection mirror (Si reflector strip). It is obvious that high-order harmonics are eliminated by the harmonic rejection mirror. The harmonic rejection mirror system provides a high-purity spectrum for the XAFS experiment.

REFERENCES

XIANGJUN, W. & YUAN, F. 2007 XAFS beamline harmonic rejection mirror technical parameters. *Technical Document of SSRF*, pp. 1–6.

ZHENJI, P. & QISHENG, H. 2006 *Precision Mechanism Design*, 1st edn. Publishing House of Machinary Industry, Beijing, 310–328.

XIAOHAN, Y. 2006 *Design Report of XAFS Beamline*, pp. 27–29.